PATENT ABSTRACTS OF JAPAN

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(71)Applicant : NIDEK CO LTD

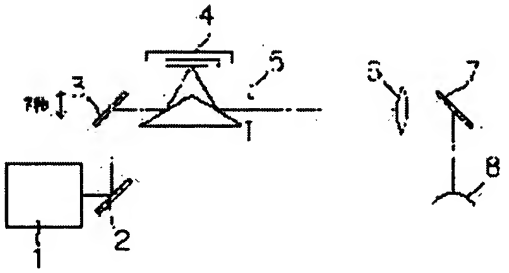
(72)Inventor : SUMIYA TOSHIBUMI

(54) ABRASION APPARATUS BY LASER BEAM

(57)Abstract:

PURPOSE: To enable abrasion with an even depth by correcting a solid difference or the like of an intensity distribution in a laser beam in an apparatus which perform an abrasion in a specified area of an object such as eyeball cornea by irradiation of the laser beam.

CONSTITUTION: Laser beam from an excimer laser light beam 1 is deflected by 90° each sequentially with a number of plane mirrors 2, 3 and 7. At this point, the plane mirror 3 moves parallel in the Z axis to make a translational scanning in the direction of an uneven intensity distribution. The laser beam is turned about an optical axis with an image rotator 4. Moreover, an abrasion area is limited with an aperture 5 allowing the altering of an opening diameter. Then, the aperture 5 is projected on an eyeball cornea 8 with a projection lens 6. In other words, the aperture 5 and the eyeball cornea 8 are set in a conjugate positional relationship for the projection lens 6. The area limited with the aperture 5 is made to form an image with the projection leans 6 on the eyeball cornea 8 to limit the abrasion area.



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CLAIMS

[Claim(s)]
[Claim 1] In the ablation equipment by the laser beam which carries out ablation of the predetermined field of an object by the exposure of a laser beam The 1st amendment means for carrying out ablation of the object to homogeneity mostly by the laser beam with uneven intensity distribution, Ablation equipment by the laser beam characterized by having the means which piles up and carries out ablation of the ablation of the predetermined depth to said predetermined field, and a means to face piling up the ablation of said predetermined depth and to rotate a beam direction.
[Claim 2]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the ablation equipment by the laser beam, and the equipment uniform [especially] the one direction of a beam cross section and suitable for the equipment which carries out ablation of the specific area of objects, such as a cornea, by the laser beam (typically excimer laser) in which the direction which intersects perpendicularly with it had uneven intensity distributions, such as Gaussian distribution.
[0002]
[Description of the Prior Art] It is required to control so that the depth which carries out ablation of the cornea front face by the laser beam which attracts attention in recent years, and carries out ablation by the laser beam in the technique of changing the curvature and correcting the ametropy of an eyeball becomes homogeneity. Then, in Japanese Patent Application No. No. (name of invention "the ablation equipment by the laser beam") 416767 [two to], and Japanese Patent Application No. No. (name of invention "the ablation equipment by the laser beam") 61211 [four to], these people had the uniform one direction of a beam cross section, and proposed the approach of performing ablation of the uniform depth, by making the advancing-side-by-side scan of the laser beam in which the direction which intersects perpendicularly with it had uneven intensity distributions, such as Gaussian distribution, carry out in the direction of uneven intensity distribution.
[0003]
[Problem(s) to be Solved by the Invention] However, this approach had the fault that the depth after ablation did not become homogeneity, when the one direction of a laser beam cross section had not become homogeneity mostly. That is, in the homogeneity of the laser beam in which outgoing radiation is carried out by the poor alignment of the resonator of laser from a laser light source, it is generated with the rose with each laser oscillation vessel. Thus, although it becomes the depth uniform in the direction which is performing (refer to drawing 3) and an advancing-side-by-side scan in not being uniform to extent which cannot disregard the intensity distribution of the direction which should be uniform, uneven distribution of a laser beam remains in the direction which intersects perpendicularly with it and which is not scanned as it is, and there is a fault that the whole ablation field does not become the uniform depth. Moreover, since a certain fault is in the optical system which carries out a light guide to the object which carries out ablation, also when it is an ununiformity on the ablation side, the same thing arises.

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[Description of the Prior Art] It is required to control so that the depth which carries out ablation of the cornea front face by the laser beam which attracts attention in recent years, and carries out ablation by the laser beam in the technique of changing the curvature and correcting the ametropy of an eyeball becomes homogeneity. Then, in Japanese Patent Application No. No. (name of invention "the ablation equipment by the laser beam") 416767 [two to], and Japanese Patent Application No. No. (name of invention "the ablation equipment by the laser beam") 61211 [four to], these people had the uniform one direction of a beam cross section, and proposed the approach of performing ablation of the uniform depth, by making the advancing-side-by-side scan of the laser beam in which the direction which intersects perpendicularly with it had uneven intensity distributions, such as Gaussian distribution, carry out in the direction of uneven intensity distribution.
[0003]
[Problem(s) to be Solved by the Invention] However, this approach had the fault that the depth after ablation did not become homogeneity, when the one direction of a laser beam cross section had not become homogeneity mostly. That is, in the homogeneity of the laser beam in which outgoing radiation is carried out by the poor alignment of the resonator of laser from a laser light source, it is generated with the rose with each laser oscillation vessel. Thus, although it becomes the depth uniform in the direction which is performing (refer to drawing 3) and an advancing-side-by-side scan in not being uniform to extent which cannot disregard the intensity distribution of the direction which should be uniform, uneven distribution of a laser beam remains in the direction which intersects perpendicularly with it and which is not scanned as it is, and there is a fault that the whole ablation field does not become the uniform depth. Moreover, since a certain fault is in the optical system which carries out a light guide to the object which carries out ablation, also when it is an ununiformity on the ablation side, the same thing arises. In view of the above-mentioned trouble, the purpose of this invention is to offer the equipment which can perform ablation of the uniform depth, also when there are [that it is uniform and] no intensity distribution of the direction which should be the original homogeneity of a laser beam cross section in the equipment which carries out an advancing-side-by-side scan, and carries out ablation of the laser beam.
[0004]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, this invention has the following descriptions.

(1) It is characterized by to have the 1st amendment means for carrying out ablation of the object for a laser beam with uneven intensity distribution to homogeneity mostly in the ablation equipment by the laser beam which carries out ablation of the predetermined field of an object by the exposure of a laser beam, the means which piles up and carries out ablation of the ablation of the predetermined depth to said predetermined field, and a means face piling up the ablation of said predetermined depth and rotate a beam direction.

[0005] (2) The one direction of a beam cross section is almost uniform, and it is characterized by to have the optical means which rotates the direction of a beam cross section to the circumference of an optical axis, and the control means which controls rotation of this optical means for said the predetermined advancing-side-by-side scan of every in the ablation equipment by the laser beam which performs uniform ablation in the direction which has uneven intensity distribution for the laser beam in which the direction which intersects perpendicularly with it had uneven intensity distributions, such as Gaussian distribution, by carrying out an advancing-side-by-side scan.

[0006]

[Example] Hereafter, one example of this invention is explained based on a drawing. Drawing 1 is the plot plan of the optical system of an example. 1 is an excimer laser, as the cross-section configuration of the laser beam by which outgoing radiation is carried out from the laser light source is shown in drawing 2 , it is distribution F (W) with the almost uniform intensity distribution of the horizontal direction (X shaft orientations) of a beam, and vertical (Y shaft orientations) intensity distribution have become Gaussian distribution (Gaussian distribution) F (H). 2, 3, and 7 are for deflecting a laser beam 90 degrees by the flat-surface mirror, and the laser beam by which outgoing radiation was horizontally carried out from the laser light source 1 is deflected upwards by the flat-surface mirror 2 90 degrees, and is again deflected horizontally by the flat-surface mirror 3. The parallel displacement of the flat-surface mirror 3 is carried out to Z shaft orientations (the direction of an arrow head), and it carries out an advancing-side-by-side scan in the direction of uneven intensity distribution. 4 is an image rotator and rotates a laser beam to the circumference of an optical axis. 5 is aperture which limits an ablation field and aperture 5 can change the path of opening. 6 is a projection lens which projects aperture 5 on the eyeball cornea 8. To the projection lens 6, aperture 5 and the eyeball cornea 8 are physical relationship [****], and the field limited by aperture 5 with the projection lens 6 carries out image formation of them on the eyeball cornea 8, and they limit an ablation field. The laser beam which passed along the projection lens 6 is caudad deflected by the flat-surface mirror 7, and reaches to the eyeball cornea 8. The eyeball cornea 8 is observed by the observation system which is not illustrated, and is positioned and fixed to position relation to equipment (not shown about a positioning means).

[0007] The scan for the ablation of the depth uniform about the equipment of the above configurations next is explained. In addition, about the advancing-side-by-side scan which carries out the parallel displacement of the flat-surface mirror 3, since it is indicated in detail by Japanese Patent Application No. No. (name of invention "the ablation equipment by the laser beam") 416767 [two to], or Japanese Patent Application No. No. (name of invention "the ablation equipment by the laser beam") 61211 [four to], please refer to. As shown in drawing 3 , when the way of one side has strong intensity-distribution [of X shaft orientations of a laser beam] F (W) like F' (W) of drawing 3 and ablation is performed with an advancing-side-by-side scan, uniformly like drawing 4 Although the direction (Y shaft orientations) which performed the advancing-side-by-side scan becomes the almost uniform depth, the direction (X shaft orientations) which did not perform an advancing-side-by-side scan has the deep one where optical reinforcement is strong, and its weaker one is shallow as the bias of intensity-distribution F' (W), and it becomes the partial depth distribution. If scan [what] also piles this up, a difference with a shallow and deep side will become very large. Then, the thing by which one side inclined toward the degree of pole deeply and which is done for ablation is lost by rotating the direction which carries out an advancing-side-by-side scan for every scan by the image rotator 4, and changing the direction where the depth inclines. According to an artificer's experimental result, the scanning direction was set up in the spacing three directions 120 degrees, and sufficient result for a cornea operation was obtained by changing the sequential scan direction for every scan. It opts for a setup of this angle of rotation in consideration of

extent of uniformity, a count of the superposition of a scan, extent of the bias of intensity distribution which are demanded. Thus, by rotating the direction which carries out an advancing-side-by-side scan to carrying out ablation only with an advancing-side-by-side scan, the bias of the intensity distribution by the individual difference of a laser oscillation machine etc. can be amended, and the ablation of the uniform depth can carry out.

[0008] Based on the correction data inputted by the keyboard etc., a microcomputer performs control in this equipment of a more than. In addition, the word which shows the direction of [under explanation of this example] is what was used since relation with the direction of energy distribution of laser was specified, and there is no exceptional semantics beyond it. Moreover, although this example projected aperture 5 on the eyeball cornea 8 with the projection lens 6 and limits the ablation field, like drawing 5 , just before the eyeball cornea 8, it may set aperture 5 and may limit an ablation field. Moreover, although the method which inserts in an optical path the filter which has a fixed absorption property as a method which acquires uniform quantity of light distribution also except the above-mentioned advancing-side-by-side scanning method is also proposed, since the individual difference of a laser oscillation machine cannot be removed, the flux of light can be rotated to the circumference of an optical axis, and this invention can be used. Although the above example gave explanation bearing the so-called wide ablation of a cornea in mind, it is clear that it can use for other processings, without exceeding the technical thought of this invention.

[0009]

[Effect of the Invention] According to this invention, in the equipment which irradiates a laser beam and carries out ablation of the fixed field, the individual difference of the intensity distribution of a laser beam etc. is amended, and uniform ablation is made possible.

[Translation done.]

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TECHNICAL FIELD

[Industrial Application] This invention relates to the ablation equipment by the laser beam, and the equipment uniform [especially] the one direction of a beam cross section and suitable for the equipment which carries out ablation of the specific area of objects, such as a cornea, by the laser beam (typically excimer laser) in which the direction which intersects perpendicularly with it had uneven intensity distributions, such as Gaussian distribution.

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PRIOR ART

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EFFECT OF THE INVENTION

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, this approach had the fault that the depth after ablation did not become homogeneity, when the one direction of a laser beam cross section had not become homogeneity mostly. That is, in the homogeneity of the laser beam in which outgoing radiation is carried out by the poor alignment of the resonator of laser from a laser light source, it is generated with the rose with each laser oscillation vessel. Thus, although it becomes the depth uniform in the direction which is performing (refer to drawing 3) and an advancing-side-by-side scan in not being uniform to extent which cannot disregard the intensity distribution of the direction which should be uniform, uneven distribution of a laser beam remains in the direction which intersects perpendicularly with it and which is not scanned as it is, and there is a fault that the whole ablation field does not become the uniform depth. Moreover, since a certain fault is in the optical system which carries out a light guide to the object which carries out ablation, also when it is an ununiformity on the ablation side, the same thing arises.

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MEANS

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[0005] (2) The one direction of a beam cross section is almost uniform, and it is characterized by to have the optical means which rotates the direction of a beam cross section to the circumference of an optical axis, and the control means which controls rotation of this optical means for said the predetermined advancing-side-by-side scan of every in the ablation equipment by the laser beam which performs uniform ablation in the direction which has uneven intensity distribution for the laser beam in which the direction which intersects perpendicularly with it had uneven intensity distributions, such as Gaussian distribution, by carrying out an advancing-side-by-side scan.

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EXAMPLE

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the plot plan of the optical system of the equipment of this example.
[Drawing 2] It is the explanatory view showing the intensity distribution of the beam of ideal excimer laser.
[Drawing 3] It is the explanatory view showing the example of the intensity distribution of the uneven laser beam which is the purpose of this invention.
[Drawing 4] It is the explanatory view showing the situation of the ablation at the time of carrying out an advancing-side-by-side scan by the uneven laser beam.
[Drawing 5] It is the plot plan of the optical system of the equipment of another mode.
[Description of Notations]
1 Excimer Laser
2, 3, 7 Flat-surface mirror
4 Image Rotator
5 Aperture
6 Projection Lens
8 Eyeball Cornea

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号

特開平6－114083

(43)公開日　平成６年(1994)４月26日

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Ａ６１Ｂ　17/36	３５０	7507－4C		

審査請求　未請求　請求項の数２(全　４　頁)

(21)出願番号　特願平4－286999

(22)出願日　平成４年(1992)９月30日

(71)出願人　000135184
株式会社ニデック
愛知県蒲郡市栄町７番９号

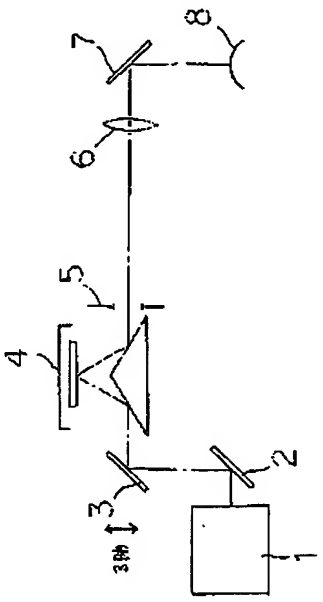
(72)発明者　角谷　俊文
愛知県蒲郡市拾石町前浜34番地14　株式会社ニデック拾石工場内

(54)【発明の名称】　レーザビームによるアブレーション装置

(57)【要約】

【目的】　レーザビームを並進スキャンしてアブレーションする装置において、レーザビーム断面の本来均一であるべき方向の強度分布が均一で無かった場合にも均一な深さのアブレーションが行える装置を提供する。

【構成】　レーザビームの照射により対象物の所定の領域をアブレーションするレーザビームによるアブレーション装置において、不均一な強度分布をもったレーザビームをほぼ均一に対象物をアブレーションするための第１補正手段と、前記所定の領域に所定の深さのアブレーションを重ね合わせてアブレーションする手段と、前記所定の深さのアブレーションを重ね合わせるに際してビーム方向を回転する手段とを有することを特徴とする。



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【特許請求の範囲】

【請求項1】　レーザビームの照射により対象物の所定の領域をアブレーションするレーザビームによるアブレーション装置において、不均一な強度分布をもったレーザビームでほぼ均一に対象物をアブレーションするための第1補正手段と、前記所定の領域に所定の深さのアブレーションを重ね合わせてアブレーションする手段と、前記所定の深さのアブレーションを重ね合わせるに際してビーム方向を回転する手段とを有することを特徴とするレーザビームによるアブレーション装置。

【請求項2】　ビーム断面の一方向がほぼ均一でそれと直交する方向がガウス分布等の不均一な強度分布をもったレーザビームを、不均一な強度分布を持つ方向に並進スキャンすることにより均一なアブレーションを行うレーザビームによるアブレーション装置において、ビーム断面の方向を光軸回りに回転させる光学手段と、前記所定の並進スキャンごとに該光学手段の回転を制御する制御手段とを有することを特徴とするレーザビームによるアブレーション装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、レーザビームによるアブレーション装置、殊にビーム断面の一方向が均一でそれと直交する方向がガウス分布等の不均一な強度分布をもったレーザビーム（代表的にはエキシマレーザ）により角膜等の対象物の特定面積をアブレーションする装置に好適な装置に関する。

【0002】

【従来の技術】近年注目されているレーザビームで角膜表面をアブレーションし、その曲率を変化させて眼球の屈折異常を矯正する手法においては、レーザビームでアブレーションする深さが均一になるように制御することが必要である。そこで、本出願人は特願平2－416767号（発明の名称「レーザビームによるアブレーション装置」）や特願平4－61211号（発明の名称「レーザビームによるアブレーション装置」）において、ビーム断面の一方向が均一でそれと直交する方向がガウス分布等の不均一な強度分布をもったレーザビームを、不均一な強度分布の方向に並進スキャンさせることにより均一な深さのアブレーションを行う方法を提案した。

【0003】

【発明が解決しようとする課題】しかしながら、この方法はレーザビーム断面の一方向がほぼ均一になっていないとアブレーション後の深さが均一にならないという欠点があった。即ち、レーザの共振器のアライメント不良等により、レーザ光源から出射されるレーザビームの均一性には個々のレーザ発振器によりバラ付きが生じている。このように均一であるべき方向の強度分布が無視できない程度に均一でない場合には（図3参照）、並進スキャンを行っている方向には均一な深さになるが、それと直交するスキャンしない方向にはレーザビームの不均一な分布がそのまま残ってしまい、アブレーション領域全体が均一な深さにならないという欠点がある。また、アブレーションする対象物へ導光する光学系に何等かの不具合があるために、アブレーション面上で不均一になっているときにも、同様なことが生じる。本発明の目的は上記問題点に鑑み、レーザビームを並進スキャンしてアブレーションする装置において、レーザビーム断面の本来均一であるべき方向の強度分布が均一で無かった場合にも均一な深さのアブレーションが行える装置を提供することにある。

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【0004】

【課題を解決するための手段】上記目的を達成するために、本発明は次のような特徴を持つ。

（1）　レーザビームの照射により対象物の所定の領域をアブレーションするレーザビームによるアブレーション装置において、不均一な強度分布をもったレーザビームをほぼ均一に対象物をアブレーションするための第1補正手段と、前記所定の領域に所定の深さのアブレーションを重ね合わせてアブレーションする手段と、前記所定の深さのアブレーションを重ね合わせるに際してビーム方向を回転する手段とを有することを特徴とする。

【0005】（2）　ビーム断面の一方向がほぼ均一でそれと直交する方向がガウス分布等の不均一な強度分布をもったレーザビームを、不均一な強度分布を持つ方向に並進スキャンすることにより均一なアブレーションを行うレーザビームによるアブレーション装置において、ビーム断面の方向を光軸回りに回転させる光学手段と、前記所定の並進スキャンごとに該光学手段の回転を制御する制御手段とを有することを特徴とする。

【0006】

【実施例】以下、本発明の一実施例を図面に基づいて説明する。図1は実施例の光学系の配置図である。1はエキシマレーザ光源であり、そのレーザ光源から出射されるレーザビームの断面形状は、図2に示すように、ビームの水平方向（X軸方向）の強度分布がほぼ均一な分布F（W）で、垂直方向（Y軸方向）の強度分布がガウシアン分布（ガウス分布）F（H）となっている。2，3，7は平面ミラーでレーザビームを90度偏向するためのものであり、レーザ光源1より水平方向に出射されたレーザビームは平面ミラー2により上方へ90度偏向され、平面ミラー3で再び水平方向に偏向される。平面ミラー3はZ軸方向（矢印方向）に平行移動し、不均一な強度分布の方向に並進スキャンする。4はイメージローテータで、レーザビームを光軸回りに回転する。5はアブレーション領域を限定するアパーチャであり、アパーチャ5は開口の径を変えることができる。6はアパーチャ5を眼球角膜8の上に投影する投影レンズである。投影レンズ6に対してアパーチャ5と眼球角膜8は共役な位置関係になっており、投影レンズ6によりアパーチ

ャ5で限定した領域が眼球角膜8の上に結像し、アブレーション領域を限定する。投影レンズ6を通ったレーザビームは、平面ミラー7で下方に偏向されて眼球角膜8へ到達する。眼球角膜8は、図示しない観察系で観察され、装置に対して所定の位置関係に位置決めされ、固定される（位置決め手段については図示せず）。

【0007】以上のような構成の装置について、次に、均一な深さのアブレーションのためのスキャンについて説明する。なお、平面ミラー3を平行移動しての並進スキャンについては、特願平2－416767号（発明の名称「レーザビームによるアブレーション装置」）又は特願平4－61211号（発明の名称「レーザビームによるアブレーション装置」）に詳しく記載されているので参照されたい。図3に示したように、レーザビームのX軸方向の強度分布F（W）が均一でなく、例えば図3のF´（W）のように片側のほうが強いような場合、並進スキャンでアブレーションを行うと、図4のように、並進スキャンを行った方向（Y軸方向）はほぼ均一な深さになるが、並進スキャンを行わなかった方向（X軸方向）は強度分布F´（W）の偏りの通りに、光強度の強いほうが深く、弱いほうが浅く、偏った深さ分布になる。これを何スキャンも重ねると浅い側と深い側との差が非常に大きくなってしまう。そこで、イメージローテータ4により、1スキャンごとに並進スキャンする方向を回転させ、深さの偏る方向を変えることによって、片側が極度に深く偏ったアブレーションされることがなくなる。発明者の実験結果によれば、スキャン方向は120度間隔の3方向に設定し、スキャンごとに順次スキャン方向を変えることにより角膜手術には十分な結果が得られた。この回転角度の設定は、要求される均一さの程度、スキャンの重ね合わせの回数や強度分布の偏りの程度等を考慮して決定される。このように、並進スキャンのみでアブレーションするのに対して、並進スキャンする方向を回転させることによってレーザ発振器等の個体差による強度分布の偏りを補正して、均一な深さのアブレーションが行うことができる。

【0008】以上の本装置における制御は、キーボード＊

＊等により入力された補正データに基づいて、マイクロコンピュータが行なう。なお、本実施例の説明中の方向を示す語は、レーザのエネルギ分布方向との関係を特定するために使用したもので、それ以上の格別な意味はない。また、本実施例はアパーチャ5を投影レンズ6で眼球角膜8に投影してアブレーション領域を限定しているが、図5のように眼球角膜8の直前にアパーチャ5をおいてアブレーション領域を限定しても良い。また、均一な光量分布を得る方式としては、上記の並進スキャン方式以外でも、一定の吸収特性を持つフィルタを光路に挿入する方式も提案されているが、レーザ発振器の個体差を取り除くことはできないので、光束を光軸回りに回転させて本発明を利用することができる。以上の実施例は角膜のいわゆるワイドアブレーションを念頭においた説明を行ったが、本発明の技術思想を越えることなく、他の加工に利用できることは明らかである。

【0009】

【発明の効果】本発明によれば、レーザビームを照射して一定領域をアブレーションする装置において、レーザビームの強度分布の個体差等を補正して均一なアブレーションが可能とする。

【図面の簡単な説明】

【図1】本実施例の装置の光学系の配置図である。

【図2】理想的なエキシマレーザのビームの強度分布を示す説明図である。

【図3】本発明の目的である不均一なレーザビームの強度分布の例を示す説明図である。

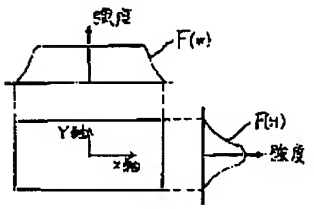
【図4】不均一なレーザビームで並進スキャンした場合のアブレーションの様子を示す説明図である。

【図5】別の態様の装置の光学系の配置図である。

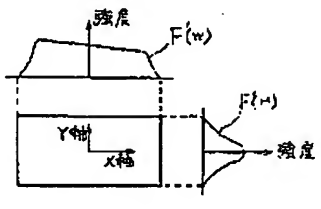
【符号の説明】

1　エキシマレーザ光源
2，3，7　平面ミラー
4　イメージローテータ
5　アパーチャ
6　投影レンズ
8　眼球角膜

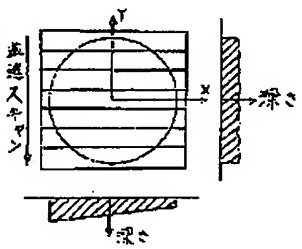
【図2】



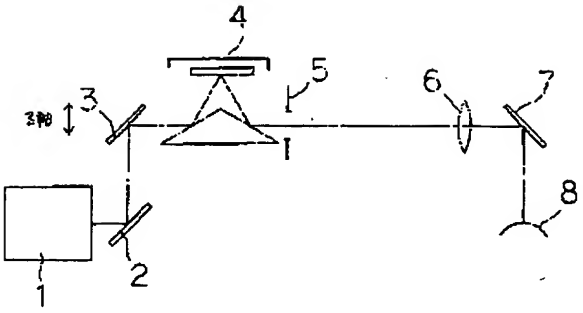
【図3】



【図4】



【図1】



【図5】